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Economic Analysis of Composite Energy Heating System in the Cold Region

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Abstract

This paper makes an analysis of the three heating mode of composite energy heating system compared with central heating. The composite energy heating system is also analyzed from the economic analysis, and the article expounds the superiority of composite energy heating system in some aspects. In terms of solar thermal storage heating mode, the reclaimed water source heat pump heating regenerative mode and composite energy heating mode, the paper carries out a detailed comparative analysis of the initial investment, annual operating cost and static payback period of these three areas. The result is that composite energy heating systems has higher initial investment but lower operating costs, combined static payback period of comparison, and the composite energy heating mode have significant economic benefits as well as a good prospect in market competitiveness.

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Keywords: Composite energy; solar thermal storage; reclaimed water source heat pump ;heating mode; economy

1. Introduction

Combined solar collector system and heat pump system in our country is still in its infancy stage. There are some reasons: on the one hand, in the past few decades of china, environmental issues did not cause enough attention. In the northern region, warm usually use area of the boiler room. Although with less investment, short period, etc., but the presence of the boiler room area still have serious environmental pollution problems, it should be eliminated by the economically developed regions abroad [1]. On the other hand is the economic capacity, in current time, these

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countries which can achieve combined solar energy collector system and pump combination are economically developed areas. It's mainly due to the investment of the complex energy supply thermal is much higher than the initial heating methods obviously. So for economic analysis of the system, it provides a theoretical basis for future production and application.

The solar thermal storage heating mode regards the solar energy as a primary heat source of heating, then turn off the water source heat pump, and reclaimed water through the solar collectors were warming into the hot water tank, and provide heat to the room by the end of the fan coil. The performance of the solar collector are the main factors for this condition, so the efficiency of the solar collector is the main factor of the heating effect and the economic costs of the whole system [2]. The efficiency of the solar collectors not only due to the product itself with a lot of parameters but also related to the collector's temperature of the heating system required. when using solar energy as the main energy, the water temperature should reach 35℃.

Reclaimed water source heat pump heating mode take the reclaimed water source heat pump as the primary heat source of system, and then turn off the solar hot water heating system, the low reclaimed water through the heating cycle of reclaimed water source heat pump, the low-grade heat is converted to high-grade heat and the heat stored in the storage tank, the storage tank provide heat to the room by the end of the fan coil. The reclaimed water source heat pump coefficient of performance is the main factors for this condition, the unit's energy efficiency ratio is the main factor of the heating effect and the economic costs of the whole system. When using the water pump as the main energy source, the condenser water temperature can reach 45℃.

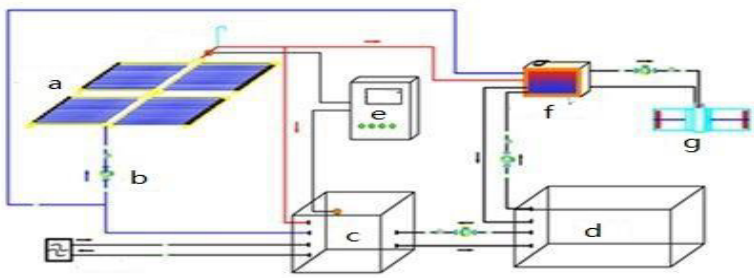

Fig. 1. Structure principle diagram of solar water source heat pump with heat storage air conditioning system. (a) solar energy collector; (b) cycling pump, (c). cryogenic water tank, (d). heat pump, (e). controller, (f). phase change energy storage hot water tank, (g). fan coil.

The composite energy heating mode regards the solar energy and reclaimed water source heat pump as the primary heat source of system, and through the storage tank to achieve the release and storage of energy, the solar hot water system through the cold tank in series evaporator of heat pump, through the solar collector to heat stored in the cold tank. When electricity prices in the valley, open reclaimed water heat pump turn the low-grade heat of cold tank into high-grade heat through the heat pump heating cycle at night, one part can store in the storage tank, other part are provided to the fan coil to meet the heating requirements of the room. When electricity prices in the valley, shut the reclaimed water source heat pump units at day, use the heat of heat storage tank provided heat for room by the fan coil.

2. Methodology

Currently, economic evaluation of solar heating system mostly adopts the method of net present value and investment recovery period, the two methods focus on the solar heating system itself investment and income status. In this paper, the economic analysis of the composite energy heating systems is to determine the most economical and reasonable solution, namely to get the most energy, less investment program. For this, paper uses static investment recovery period, comparison the capital investment of different types of heating systems when provide the same amount of energy case. For composite energy heating systems, capital investment in its effective use period is mainly used for: the initial investment: use to buy collectors, heat circulating pump, water tank, the

reclaimed water source heat pump, electric auxiliary heater, phase change material, fans coil, the controller and the costs incurred during the installation process; operating costs: during use system operation costs and maintenance costs [3].

The payback period of the project is to cover the time of all investment by the net investment. Static is not considered capital's value of time. System payback period is calculated based on other heating methods, the increased investment payback period based on static recovery calculation.

Calculate the given parameters: The meteorological parameters in accordance with heating and air conditioning indoor and outdoor calculation temperature, days of period and the heating degree days in Shenyang region. Calculate the object is a company's workshop in Shenyang for calculating object, in accordance with the actual situation, take the maximum heating load 60W/m2, the indoor temperature is maintained at 15℃, room size is 30m2, winter heating heat load 1800W. The energy consumption indicators: peak electricity price is 1.1898 Yuan per kW • h; Valley electricity price 0.3966 Yuan per kW • h. Calorific value and price of various fuels are shown in Table 1.

Table 1. value and price of fuel calorific.

Fuel type	Combustion value (cal/kg)	Average thermal efficiency	Fuel price(Yuan/kg)
Coal	4300	64%	0.45
Oil	10200	85%	4.2
Natural gas	9000	75%	2.2
Electricity	860	95%	0.79

The main economic evaluation are the initial investment, the total annual cost and the annual operating costs. The initial investment refers to the various parts investments of a composite energy heating systems, which include: purchase of equipment costs, equipment Installation fees and other expenses. The total annual cost refers to the running costs of each part of the system, such as water, electricity, sewage charges, management salaries, management fees, equipment depreciation fees and equipment maintenance, overhaul costs. The annual operating costs refers to the total cost deduct equipment depreciation fees.

3. Results and discussions

According to the economic evaluation method previously proposed, respectively, calculate four kinds of heating way economic parameters, each program separately calculate the initial investment, annual operating costs and payback period, the comparison results are as follows:

The system initial investment calculation is as follows: The price of the solar thermal storage heating system parts as follows: the price of the solar collector is 25000 Yuan, the price of the heat storage water tank is 8370 Yuan, the price of the fan coil is 1700 Yuan, the price of the price of the ends with hot circulating pump is 450 Yuan, the price of the solar energy circulating pump is 700 Yuan.

Followings are the price of the reclaimed water source heat pump heating system parts: the price of the reclaimed water source heat pump units is 35000 Yuan, the price of the heat storage water tank is 8370 Yuan, the price of the Fan coil is 1700 Yuan, the price of the price of the ends with hot circulating pump is 450 Yuan, the price of the circulating pump of hot is 700 Yuan, the price of the circulating pump of take hot is 36220 Yuan.

The price of the central heating system parts are as follows: the price of the plate heat exchanger is 6500 Yuan, the price of the hot water circulating pump is 2500 Yuan, the price of the make-up water pump is 2000 Yuan, the price of the make-up water tank is 2500 Yuan, the price of the water softener is 1200 Yuan, the price of the constant pressure water tank is 4500 Yuan, the price of the radiator is 1500 Yuan, the price of the integrated net fee is 6000 Yuan.

The price of the composite energy heating system parts are as follows: the price of the reclaimed water source heat pump is 6500 Yuan, the price of the heat storage water tank is 8370 Yuan, the price of the fan coil is 1700 Yuan, the price of the ends with hot circulating pump is 450 Yuan, the price of the circulating pump of hot is 700 Yuan,

the price of the Solar collector is 25000 Yuan, the price of the circulating pump of take hot is 36220 Yuan, the price of the solar energy circulating pump is 700 Yuan.

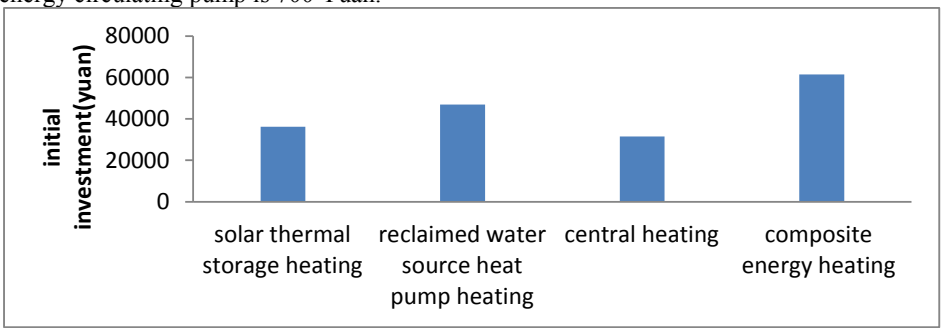

Fig. 2. Contrast of the system initial investment.

The diagram shows the comparison of four kinds of heating system of initial investment, the initial investment includes all investment projects from the heat source to the end device. From the figure can be seen that the highest initial investment is composite energy heating mode, second is the reclaimed water source heat pump heating mode, solar thermal storage heating mode and central heating mode similar initial investment phase, which is slightly higher heating mode of solar thermal storage heating mode, central heating system slightly lower.

The system operating cost calculation is as follows:

Solar thermal storage heating mode operating costs include: electricity, sewage charges, management salaries, equipment depreciation fees and equipment maintenance, overhaul costs. Specifically, electricity cost is 3902.544 Yuan per year, other costs is 1500 Yuan per year. Solar thermal storage heating system total operating costs is 5402.544 Yuan per year. To the reclaimed water source heat pump heating system operating costs include: electricity cost is 2718.69 Yuan per year, other costs is 2000 Yuan per year. Reclaimed water source heat pump heating system in the total operating costs of 4718.693 Yuan per year. To the composite energy heating systems include: electricity cost is 1055.381 Yuan per year, other costs is 700 Yuan per year. The composite energy heating system in the total operating costs of 1755.381 Yuan per year. To central heating system, Shenyang area when using the central heating system, a fee of 28 Yuan per square meter, the annual operating cost of the system is 3080 Yuan per year, the management fees, equipment depreciation and equipment maintenance, overhaul costs is 3,000 Yuan per year. The central heating system's total operating costs for 6080 Yuan per year.

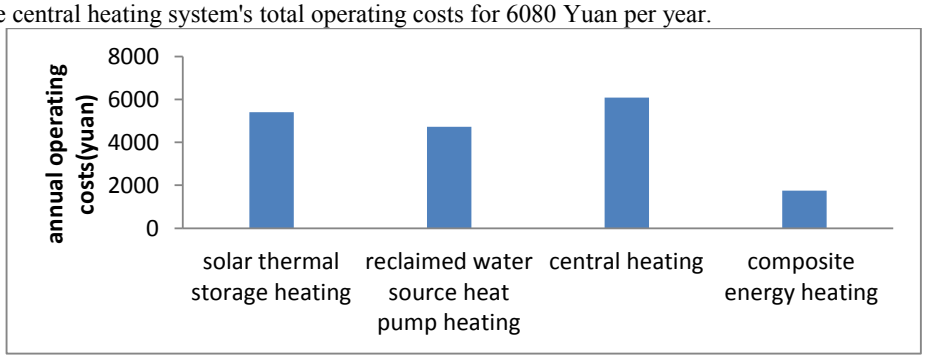

Fig. 3. Contrast of the system operation cost.

The diagram shows the annual operating cost comparison of four heating mode, it can be seen from the figure, solar thermal storage heating mode is the highest operation cost, the second is reclaimed water source heat pump heating mode, central heating and composite energy heating mode operation cost almost the same, wherein the composite energy heating mode is slightly lower, central heating slightly higher. From the analysis of the figure, the higher initial investment is composite energy heating mode, but lower operating costs, so alone compare initial

investment and annual operating costs are relatively no compare economic program to be. Static payback period is calculated as follows:

$$Y = \frac{W_1}{W_2} \quad (1)$$

where Y is a simple payback period, W1 is increasing of initial investment compared to other heating methods and W2 is simple saving costs.

The increasing payback period of composite energy heating mode compared to other heating methods is as follows: the static payback period compared to solar thermal storage heating mode is 6.9 years, compared to the reclaimed water source heat pump heating mode is 4.9 years, compared to central heating is 7 years.

After analysis can be seen reclaimed water source heat pump heating mode compared to the solar thermal storage heating mode static payback period of 6.9 years, compared to the reclaimed water source heat pump heating mode static payback period of 4.9 years, as opposed to centralized heating net payback period is 7 years, there are certain economic advantages [4].

This paper from technical economic about composite energy heating system is an analysis and evaluation, pointing out the advantages of the composite energy heating systems in technology applications, while its economy has been detailed analysis. About solar thermal storage heating mode，the reclaimed water source heat pump heating regenerative mode and composite energy heating mode，we carried out a detailed comparative analysis of the initial investment, annual operating cost, static payback period of these three areas.

4. Conclusions

The use of composite energy heating system for heating the room, even if the outdoor temperature is low, the system can fully benefit with a base of solar energy, reclaimed water and other resources on the temperature of the room to meet the requirements, the system work more stable [5].

Composite energy heating systems in engineering the average coefficient of performance is 6.3, which coefficients reaches more than twice in the average performance of conventional air conditioning system with its remarkable energy-saving effect.

Composite energy heating systems compared to conventional central heating systems can save standard coal 802 kg in per heating season, reducing a lot due to incomplete combustion of coal in air pollutant emissions, it is significant environmental benefits.

By the comparative analysis about composite energy heating mode, solar thermal storage heating mode, the reclaimed water source heat pump heating mode, and central heating mode of economic, results, the higher initial investment is composite energy heating mode, but lower operating costs, combined static payback period of comparison, the composite energy heating mode have significant economic benefits.

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